Institute for Materials Science

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IMS Distinguished Lecture Series

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Department of Materials Science & Engineering
Department of Physics - Institute of Materials Science
University of Connecticut

Materials by Design: Electrocaloric Materials for Waste Heat Recovery

Wednesday, January 18, 2017
2:00 - 3:00 pm
MSL Auditorium (TA-03 - Bldg 1698 - Room A103)

Abstract: Electrocaloric materials have emerged as a viable alternative to thermoelectrics and magneto-calorics in solid state heating/cooling and waste heat recovery applications. Electrocaloric and pyroelectric responses describe converse effects, wherein an adiabatic change in temperature occurs in response to an applied electric field, or a change in the electric polarization occurs in response to a change in temperature. Following the discovery of a giant electrothermal response in ferroelectric thin films, there have been a large interested devoted to the development of ferroelectric-based electrocaloric materials. Indeed, some of the very best polymeric and ceramic materials now show temperature lifts that make them intriguing candidates to replace conventional vapor compression systems. There is still much to be gained in achieving total system level improvements from stepwise performance improvements in materials. To date, however, many of the prior performance gains have been derived from experiments based upon experimental intuition rather than guided by theoretical analysis.

Here, we present a first step towards the material design approach through a complete analysis of intrinsic adiabatic temperature changes in a representative selection of perovskite ferroelectrics, using theoretical tools supported by carefully measured heat capacities. Our results indicate that the intrinsic adiabatic temperature changes in ceramic based relaxor-ferroelectrics are substantial and relatively temperature insensitive. Furthermore, we show that one can find perovskite ferroelectrics with exceedingly large intrinsic electrocaloric response at high electric fields. In fact, we predict a giant electrocaloric response of 28oC at 1MV/cm in PbTiO3. This is similar to some of the best responses experimentally observed at similar fields in polymeric ferroelectrics. Such high field response can be realized in several micrometer thick films, thus establishing these materials as extremely promising candidates for electrocaloric elements. This work provides a “calculus” by which material systems can be further explored and assessed.

Bio: S. Pamir Alpay received his PhD in Materials Science and Engineering in 1999 from the University of Maryland. He was a post-doctoral research associate at the Materials Research Center at the University of Maryland until 2001. Alpay then joined the Department of Materials Science and Engineering (MSE) of the University of Connecticut (UConn) in 2001 as an Assistant Professor. Prof. Alpay is currently serving as the Department Head of MSE at UConn, is a member of the Institute of Materials Science and has a joint appointment with the Department of Physics. His research focuses on materials for electromagnetic applications and materials modeling. Alpay received the NSF-CAREER Award in 2001 and the UConn School of Engineering Outstanding Junior Faculty Award in 2004. He is a Fellow of the American Physical Society, an elected member of the Connecticut Academy of Science and Engineering (CASE), and an Editor for the Journal of Materials Science. Alpay is the author of >150 publications in peer-reviewed journals, 20 peer-reviewed conference proceedings, five invited book chapters, and an invited book on compositionally graded ferroelectric materials. He delivered ~100 invited talks/seminars in international meetings and at academic institutions, national laboratories, and industry.

To be on Professor Alpay’s Agenda, to participate in the Early Career Lunch, or for general information contact
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Hosted by Alexander Balatsky * Director of the Institute for Materials Science

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